

LITERAL

Method and arrangement for the energy-saving operation
of dishwashers

Field of the invention

5 The invention relates to a method and an arrangement by
means of which dishwashers can be operated with more
energy being saved. One particular aim of the invention
is to allow energy-saving operation of multiple tank
dishwashers with washing zones, a rinsing zone and a
10 drying zone.

Prior art

Known machines, such as the dishwashing and drying
15 installation described in DE 44 36 359 C2, typically
have heaters installed for the individual loads, that
is to say for the individual zones. These heaters are
sufficient to cover the respective worst-case power
demand. The worst-case power demand is in this case
20 that amount of power which is required for the rated
power of the machine.

The heating power levels in the individual zones
differ, depending on the method being used. The
25 installed heating power levels are in each case
switched on and off depending on the instantaneous
power demand. The addition of the heating power levels
which are required for the rated power in each case
results in the maximum connection level.

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By way of example, Figure 1 illustrates a multiple tank
dishwasher 110 corresponding to the prior art. In these
dishwashers, the item 9 being washed is passed to a
transport device 11 in the inlet 1, and is then
35 transported in the direction 10 through zones of
precleaning 2, main cleaning 3, pump rinsing 4,

fresh-water rinsing 5, heat recovery 6, dry zone 7 and the outlet 8.

Once the machine 110 has been switched on, the respective cleaner solution in the tanks 13, 17, 21 is provided in the zones 2, 3, 4 and is raised to the operating temperature by means of heaters 14, 18, 22. The machine is ready to operate once respectively preset nominal-value temperatures have been reached in the tanks 13, 17, 21.

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The transport can then be switched on, with the item 9 being washed being placed on the transport device 11, and then being transported through the zones 1 to 8. During this process, the item 9 being washed has appropriate cleaning solutions applied to it via pumps 15, 19, 23 and via the washing systems 16, 20, 24, and is cleaned.

The item 9 being washed has fresh water applied to it via a spraying system 28 in the fresh-water rinsing 5, with this fresh water previously having been heated via a heat exchanger 29 and a heating element 26. Residues of the cleaning solutions are washed away during this process. Fresh water is preheated in the heat exchanger 29 by means of hot exhaust air 31 from the dishwasher 110. The fresh water is then heated further in a heating element 26, in order then to be supplied to the spraying system 28.

After being rinsed in the zone 5, the item 9 being washed then has hot air 34 applied to it in the dry zone 7 via a fan 32 and a heater 33, and is thus dried. The cleaned, rinsed and dried item 9 being washed is then removed in the outlet 8 of the dishwasher 110.

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By way of example, Table 1 lists typical power levels of loads in the illustrated machine 110. In this case, only the power levels of the heating elements 14, 18,

22, 26 and 33 are listed, for simplicity. This simplified example ignores the power levels required for the pumps 15, 19 and 23 used for the spraying systems 16, 20 and 24, as well as the drive power
5 required for driving the transport device 11, the exhaust-air fan 30, the fan in the dry zone 32 and further loads that are not illustrated. The connection level for the heating elements in this example corresponding to the prior art results in a total power
10 of 47 kW.

Only the heaters 14, 18 and 22 are typically switched on in the phase of heating the tanks 13, 17 and 21. This results in a power level in the heating-up phase
15 (starting phase) of $12 + 9 + 3 = 24$ kW. The heating elements 26 and 33 are in this case typically not switched on. This 24 kW results in a typical heating-up time for the tanks 13, 17 and 21 and thus a specific predetermined time before the dishwasher 110 is ready
20 to operate.

During the operating phase, the heaters 26 and 33 are then additionally switched on, with an additional heating power of 18 and 9 kW, respectively, in order to
25 heat the fresh water and the drying air. In this operating phase, all of the heating elements 14, 18, 22, 26 and 33 are then switched on and off depending on whether the respective predetermined nominal temperatures have or have not been reached in these
30 zones. If the predetermined nominal temperatures have not been reached, only the installed power levels are in each case available for subsequent heating. The heating powers of the heating elements 14, 18, 22, 26 and 33 are typically switched on and off at different
35 times.

Dishwashers of the described type have numerous disadvantages which generally result from the operation

of dishwashers such as these being very inefficient in terms of energy use. These disadvantages are thus associated in particular with the fact that the amount of electrical power supplied must not exceed a
5 predetermined maximum value. This maximum value governs, in particular, the design of the electrical supply cables and the electronics. The individual loads in the dishwasher are generally matched to the respective demand independently of one another, so that
10 all of the loads are operated at the maximum power in the worst case. Loads are in this case typically operated in such a way that they are either switched off or switched on at a predetermined power level. The maximum value of the total supplied power must
15 therefore be matched to this "worst case", in which all the loads are operated at the maximum power level.

Furthermore, dishwashers of the described type are frequently found to be very slow and cumbersome,
20 particularly in the starting phase before they are ready to operate. This is particularly due to the fact that critical heating elements which, for example, are intended to control the operating temperature being reached in the tanks 13, 17 and 21 can be operated only
25 at a respectively predetermined maximum power resulting from the abovementioned "worst case" scenario.

Object of the invention

30 The object of the invention is thus to specify a method and an arrangement by means of which dishwashers can be designed such that more energy is saved and they are more flexible.

35 Description of the invention

This object is achieved by the invention with the features of the independent claims. Advantageous developments are described in the dependent claims.

5 A method is proposed for energy-saving operation of a dishwasher, in particular for washing dishes or medical appliances, as well as an apparatus for in each case carrying out the method in one of the described refinements. The dishwasher may, in particular, be a
10 multiple tank dishwasher. The method steps described in the following text need not necessarily be carried out in the described sequence. Further method steps, which are not included, may also be carried out. Reference is made to Figure 2 for the numbering of the method steps.

15 The dishwasher should have a total number $N \geq 2$ of electrical load elements. As already described above, these load elements may, for example, be heating elements, pump elements, fans or drive elements.
20 Further load elements may also be included, for example power supplies for controllers or computers.

In this case, a group of n electrical load elements is assigned a maximum electrical total power p_{\max} (step 210
25 in Figure 2), where n is a natural number and $n > 1$. Furthermore, n should be less than or equal to the total number N of electrical load elements in the dishwasher: $n \leq N$. All or else only some of the load elements in the dishwasher can thus also be included in
30 the method.

Furthermore, each electrical load element i in the group of n electrical load elements is assigned a finite number m_i of discrete electrical power levels p_{ij}
35 (step 220 in Figure 2). In this case, m_i should assume at least the value 2. The first index i of the discrete electrical power levels p_{ij} is a natural number which successively numbers the electrical load elements, and

in which case $i \in \{1, \dots, n\}$. The individual power levels for a specific load i are numbered successively by the second index j . In this case, j is likewise a natural number, which is greater than zero and can assume the maximum value m_i : $0 < j \leq m_i$.

A maximum power level $p_{i\max}$ is assigned to each load element i , so that p_{ij} can assume at most the value $p_{i\max}$ for all i, j . The sum of all the maximum power levels $p_{i\max}$ forms a so-called "worst-case total power" p_{worst} . In this case, the maximum electrical total power p_{\max} should be less than the worst-case total power p_{worst} . In contrast to the prior art, in which p_{worst} is typically shared directly between the individual load elements, this condition ensures that the total power demand of the dishwasher is reduced.

Furthermore, each load element i is assigned a so-called "regular power level" $p_{i\text{reg}}$, which is between zero and the respective maximum power level $p_{i\max}$. These regular power levels are in fact chosen such that the sum of the regular power levels $p_{i\text{reg}}$ over all the load elements i is just equal to the maximum electrical total power p_{\max} . The maximum electrical total power is thus "shared" between the individual load elements i .

Furthermore, a so-called "demand determination step" is carried out (step 230 in Figure 2). In this case, an optimum combination of power levels $p_{ij}(B)$ is selected depending on the operating state B of the dishwasher, with the selected power level $p_{ij}(B)$ for each load element i being matched to the power demand of the load i in the operating state B .

By way of example, an operating state is in this case characterized by an operating phase in which the dishwasher is actually being operated (for example the starting phase, switched-on phase, load regulation

phase) or, for example additionally, by corresponding operating parameters or operating state variables, for example by means of measured values of specific sensors in the dishwasher (for example temperature sensors, flow sensors, pressure sensors). By way of example, each operating state B can thus be characterized by an operating state variable F and/or by a plurality of operating state variables, in which case the operating phase variable F may assume at least three discrete values F_1 , F_2 , F_3 . In this case, F_1 denotes a starting phase of operation of the dishwasher, F_2 a switched-on phase of operation of the dishwasher, and F_3 a load regulation phase of operation of the dishwasher.

By way of example, in the demand determination step, more power can be supplied to specific heating elements in a starting phase than in a subsequent operating phase. Furthermore, the power levels $p_{ij}(B)$ are selected such that the sum of all the power levels $p_{ij}(B)$ assumes at most the value p_{\max} . Ideally, the method is in this case carried out such that this sum just reaches the value p_{\max} again, or is only slightly less than it, so that the total available power is optimally used. This ensures that, as in the case of the prior art as well, each heating element is operated with its maximum permissible power, when required.

In contrast to the prior art, however, other load elements for which there is little requirement at that time have correspondingly less power applied to them in this case. The power is thus distributed, controlled by the respective demand, in accordance with the discrete power levels p_{ij} of the individual load elements, in which case the total sum of the power levels is in each case as high as possible, and the greatest possible power is applied at any given instant to the heaviest required load. In this case, priorities can also be preset, that is to say by way of example that the

maximum possible power should initially be allocated to specific heating elements in the dishwasher, in particular specific heating elements which heat water in one or more water tanks and/or water circuits, before power is applied to other elements with a lower priority.

In practice, the demand-dependent allocation of electrical power levels can be carried out, for example, by using a computer for control purposes. By way of example, specific scenarios (operating states, value ranges of operating state variables) can be stored in an electronic memory, for example in an electronic table or look-up table. Each possible scenario or operating state B can be allocated an optimum set of power levels simply by reading the electronic table, so that the sum of these allocated power levels as far as possible reaches the maximum permissible total power p_{\max} , or is below it only to the least possible extent.

The fixed power levels can in practice be achieved, for example, by providing fixed power levels in the individual electrical supplies to the individual load elements themselves, between which it is just necessary to switch. For example, specific voltage dividers with fixed predetermined divider stages can be used. There is then no need for complex and expensive analog regulators. Alternatively and/or additionally, a software solution could also be used, or analog power regulators.

In practice, it has been found to be particularly advantageous to also be able to use a power level zero, that is to say when a power level for each load element exists for which no electrical power is applied to that load element. Furthermore, it is advantageous for three and only three power levels to be provided for each

load element, in particular zero, p_{ireg} and p_{imax} . This simple refinement can be implemented particularly easily in the circuitry and in its own right has all of the advantages of the invention.

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Once the optimum combination of power levels has been determined in this way for the respective operating state, each load i has the respective power determined for it applied to it (step 240 in Figure 2). In this case, it should be noted that the allocation of the power in practice highly probably never corresponds completely exactly to the respective nominal value for example because technical tolerances (for example tolerances in electronic components) can result in minor discrepancies. However, the discrepancies in the power levels which are actually applied to the loads from the respective nominal value are advantageously no more than 10%, and preferably even no more than 5%.

20 The described method, in which the maximum electrical supplied power is governed not by the sum of the maximum individual power levels but by the sum of the "normal" power levels, offers a number of advantages over conventional methods. In particular, the described method typically makes it possible to save 20-30% of the power, which is actually financially significant in large concerns.

Furthermore, the described method also in some cases has a considerable influence on the functionality of the dishwasher. For example, the described method can be used to considerably shorten, in particular, the starting phase or heating-up phase, that is to say the phase between the dishwasher being brought into use and it actually being ready to operate. This not only results in better user friendliness, but in turn also reduces the total energy demand since the starting

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phase cannot be used in a financially worthwhile manner despite the demand for electrical energy.

The method described above can be extended by a number of advantageous refinements, with the aim of always observing the relationships described above between the individual characteristic variables, in particular between the various power levels of the individual load elements. This means in particular that the total sum of the assigned power levels for the individual loads should not exceed the maximum permissible total power P_{\max} .

In one advantageous refinement of the invention, the dishwasher is thus started first of all, thus marking a starting phase. At least one temperature of at least one washing liquid, in particular a temperature of water in at least one water tank and/or water circuit, is then detected. In particular, this may be done by means of one or more temperature sensors.

The at least one washing liquid is then heated by means of at least one heating element, with the respective heating element being used for heating purposes (which represents the load element l where $l \in \{1, \dots, n\}$) being operated at the maximum power level $p_{l\max}$ associated with this heating element. The maximum possible electrical power is thus initially supplied to the heating elements that are required for the starting phase. However, in order to ensure that the total sum of the individual power levels of the load elements does not exceed the maximum permissible total power p_{\max} , the power for at least one further load element, which is not required to such a major extent in the starting phase, must be reduced appropriately. At least one load element q , which is not the same as the heating element l , where $q \in \{1, \dots, n\}$ and $q \neq l$ is thus operated at a lower power level than the regular power

level p_{qreg} associated with this load element q . By way of example, this may be the power level $p_{qreg} = 0$, that is to say the load element which is required to a lesser extent is completely switched off.

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As soon as the at least one temperature of the at least one washing liquid reaches or has exceeded a predetermined nominal value, a switched-on phase is then started. In this switched-on phase, the power of
10 all the load elements i is then initially set to the respectively associated regular power level p_{ireg} .

As a result, for example, of various disturbances or environmental influences, it is, however, possible for
15 disturbances to occur during operation of the dishwasher, in the event of which, for example, specific temperatures in various areas fall below a predetermined nominal value. In one advantageous development, at least one operating state variable is
20 thus detected, in which case, as already mentioned above, this may by way of example be the measured values from various sensors.

A nominal value is allocated to at least one operating
25 state variable. This may, for example, be preset nominal values, for example nominal values stored in a data memory or in an electronic table, or else nominal values which can be influenced by a user. By way of example, a user can thus vary specific nominal presets
30 during operation of the machine, for example the temperature in specific areas of the machine, thus making it possible to influence the operation of the dishwasher.

35 If it is found (for example by means of a simple comparator) that the value of the at least one operating state variable differs by more than a predetermined tolerance from the respectively

associated nominal value, a load regulation phase is started. This load regulation phase may, for example, be designed such that at least one load element r where $r \in \{1, \dots, n\}$ which influences the corresponding
5 incorrect operating state variable is operated at a power level other than the regular power level p_{reg} .

By way of example, if it is found that the temperature in a liquid tank is excessively low, it is thus
10 possible to temporarily operate a heating element which heats the liquid in this tank at an increased power level, for example at the maximum associated power p_{imax} . As described above, the power of at least one further load element must, of course, be reduced in
15 this case in order to ensure that the total sum of the power levels does not exceed the maximum total power p_{max} . Once again, this allocation of power levels can be carried out, for example, by an appropriate set of power levels for this scenario being stored in an
20 electronic table.

This load regulation operation is continued until the at least one operating state variable once again assumes a value which differs by not more than the
25 predetermined tolerance from its nominal value.

Furthermore, the scope of the invention covers a computer program which carries out one of the embodiments of the method according to the invention
30 when run on a computer or computer network.

The scope of the invention also covers a computer program with program-code means in order to carry out one of the refinements of the method according to the
35 invention when the program is run on a computer or a computer network. In particular, the program-code means may be stored on a computer-legible data storage medium.

Further details and features of the invention will become evident from the following description of preferred exemplary embodiments in conjunction with the dependent claims. In this case, the respective features can be implemented in their own right or in groups of two or more combined with one another. The invention is not restricted to the exemplary embodiments.

10 The exemplary embodiments are illustrated schematically in the figures. The same reference numbers in the individual figures in this case denote identical or functionally identical elements, or elements whose functions correspond to one another. In detail:

15 Figure 1 shows a belt transport dishwasher corresponding to the prior art;

20 Figure 2 shows a flowchart of one simple refinement of the method according to the invention;

Figure 3 shows a schematic arrangement for carrying out the described method with a belt transport dishwasher; and

25 Figure 4 shows a schematic arrangement relating to the described method being carried out with a single-chamber dishwasher.

30 Figure 3 illustrates one preferred arrangement, by means of which the method as described above can be carried out. The apparatus has a continuous-flow dishwasher, specifically a belt transport dishwasher, analogous to the dishwasher 110 illustrated in
35 Figure 1. The illustrated elements correspond to the respective elements of the dishwasher 110 in Figure 1, and their functions are the same as them. Alternatively, further types of dishwashers could also

be used. In addition, the arrangement in Figure 3 has a computer system with a central processor unit 312 and a data memory 314 (for example a volatile or non-volatile memory). The computer system 310 is connected via a
5 main controller 316 to the dishwasher 110, so that all of the major functions of the dishwasher can be controlled via the computer system 310.

Furthermore, the apparatus illustrated in Figure 3 has
10 a plurality of temperature sensors 318, which can detect the temperature in the liquid tanks 13, 17 and 21 as well as in the air flow 34 of the fan 32, as well as at various points in the liquid system 28 for the fresh-water rinsing 28. Further temperature sensors as
15 well as additional sensors, for example for pressure or flow rate, can be fitted at various points in the system. The data measured by the temperature sensors 318 is detected by means of a central measured-data detection unit 320, is digitized and is made available
20 to the computer system 310.

Furthermore, in this exemplary embodiment, the system has five electrical power supplies 322, 324, 326, 328 and 330, which supply electrical power to the heating
25 elements 14, 18, 22, 26 and 33. The electrical power supplies 322, 324, 326, 328 and 330 are each connected to respective externally controllable electrical power regulators 332, 334, 336, 338 and 340. These externally controllable electrical power regulators 332, 334, 336,
30 338 and 340 control the electrical power from the electrical power supplies 322, 324, 326, 328 and 330 and are themselves in turn connected to the computer system 310, and can be controlled via it.

35 In addition to the heating elements 14, 18, 22, 26 and 33, pumps 15, 19 and 23 are also provided with corresponding power regulators, which can be controlled

by the computer system. These power regulators are not illustrated in Figure 3, for simplicity.

The described method can be carried out by means of the arrangement as illustrated in Figure 3, by way of example as follows. The maximum total power p_{\max} for which the overall system is designed is assumed in this example to be 45 kW. First of all, specific power levels are allocated to the individual load elements. These power levels are typically preset, in which case, for example, different electrical circuits, in particular in the externally controllable power regulators 332, 334, 336, 338 and 340 and in the power regulators for the pumps 15, 19 and 23, which are not illustrated, can be used. It is possible to switch between these individual electrical circuits, controlled by the computer system 310, so that different power levels can be applied to the respectively associated loads 14, 18, 22, 26, 33, 15, 19 and 23.

By way of example, Table 2 shows an allocation such as this of discrete power levels to the individual load elements. In this case, the load element with the associated reference symbol is in each case shown in the first column. The respective discrete power levels are listed in the second column. All of the power levels are stated in kilowatts. In this case, in this simple example, the heating elements 14, 18, 22 and 26 each have three power levels, specifically p_{\max} , p_{ireg} and p_{\min} . The pumps 15, 19 and 23 in this example have only two power levels, specifically $p_{\max} = p_{\text{ireg}}$ and p_{\min} . The lowest power level p_{\min} is set to the value zero in this example for all of the listed loads.

Examples for power levels in various operating phases are shown in the third, the fourth and the fifth column, specifically in the starting phase (third

column), the switched-on phase (fourth column) and the load regulation phase. Typical numerical values for this example are illustrated in the fourth column, based on a conventional control method for the
5 dishwasher 110 illustrated in Figure 3.

In the starting phase, that is to say immediately after the dishwasher 110 has been brought into use, the water tanks 13, 17 and 21 must be raised to the required
10 operating temperature, before the washing operation of the machine can be started. In this starting phase, the maximum power is thus allocated to the heating elements 14, 18 and 22. The heating 26 for the continuous-flow heater, the drying heating 33 and the pumps 15, 19 and
15 23 are in contrast not yet required in this starting phase, and are thus set to the minimum power, that is to say in this case to a power level of zero. Overall, the total power level for all of the loads in this starting phase is calculated to be a power of 45 kW,
20 which thus corresponds exactly to the predetermined maximum value p_{\max} . Alternatively, the sum of the individual powers could also be less than p_{\max} , but in no case more than it.

25 As soon as the signal from the temperature sensors 318 indicates that the predetermined nominal temperatures (which for example are stored in the data memory 314 in the computer system 310) have been reached in the tanks 13, 17 and 21, the computer system 310 initiates the
30 switched-on phase. Various intermediate phase are also feasible, in which, for example, the temperature in individual tanks has already reached the nominal value, but has not in others.

35 In the switched-on phase, the regular power values p_{rireg} are then first of all applied to all of the loads. As is once again shown in the lowest line of Table 2, the sum of these p_{rireg} regular power levels is also 45 kW in

this case. Once again, as an alternative, the sum of the individual power levels could also be less than p_{\max} , but in no case greater than it. The washing process can then be carried out in the dishwasher in the switched-on phase, and the machine is ready to operate.

If the computer system finds in the switched-on phase that one or more of the detected sensor values, for example the measured values from individual temperature sensors 318, have risen above or fallen below predetermined nominal values (which by way of example are once again stored in the data memory 314) by more than respectively likewise stored tolerance values, then the computer system 310 switches over to a load regulation phase. Depending on the nature of the discrepancy, appropriate action instructions in the form of power levels for corresponding loads can, for example, be stored in one or more look-up tables in the data memory 314.

As a simple example, the fifth column in Table 2 thus shows a situation as to how, for example, it would be possible to react to an increased temperature in the precleaning tank 13 and to a temperature in the main cleaning tank 17 that is lower than the associated nominal value. The power of the heating element 14 is set in an appropriate manner from the regular value of 9 kW to the minimum value of 0 kW, while in contrast the power of the heating element 18 is raised from the regular value of 6 kW to the maximum value of 15 kW. As is also evident from the last line in Table 2, the total sum of the powers applied in this case is 43 kW, that is to say slightly below the maximum permissible value of 45 kW. However, in this case, no power level for a load element is set to a higher power level than that which would exceed the maximum permissible total

power p_{\max} . Thus, the available power range is therefore optimally used in this case as well.

As soon as the computer system 310 finds that the
5 predetermined nominal values have been reached again
(except for appropriate tolerable discrepancies), a
switchover is once again carried out to regular
switched-on operation. If discrepancies are found
again, then the described process of load regulation is
10 repeated as appropriate.

For comparison, the last column in Table 2 also shows
corresponding power levels of conventional systems, in
which only one specific load can in each case be
15 switched on or off. As can be seen, a total power of
78 kW can occur in the worst case here, for which the
system must be designed.

Analogously to the example, as illustrated in Figure 3,
20 of a multiple chamber dishwasher, the method can also
be transferred to single-chamber dishwashers, or to
further dishwasher types. One corresponding arrangement
is illustrated in Figure 4.

25 The arrangement has a single-chamber dishwasher 410,
which may, for example, be a front-loading
single-chamber dishwasher or a through-feed machine. A
basket 412 is held in the single-chamber dishwasher 410
in order to hold the item 414 to be washed.
30 Furthermore, the dishwasher 410 has a tank 416 for
washing lye, which can be heated via a heating element
418. Washing liquid can be applied to the item 414 to
be washed from this tank for washing lye 416, by means
of a circulation pump 420 and via a washing system for
35 washing lye 422, which is provided with a plurality of
nozzles 424.

Furthermore, the dishwasher 410 has a fresh-water tank 426, which is in the form of a boiler. The fresh-water tank 426 can be filled with fresh water 430 via a filling valve 428. In addition, the fresh-water tank
5 has a heating element 432, by means of which the fresh water 430 can be heated for rinsing at increased temperatures. The fresh-water tank 426 is in this case always filled with fresh water 430 as far as the level 434 at which the heating element 432 is covered. In
10 order to avoid overpressure in the fresh-water tank 426 during heating, the fresh-water tank 426 is connected to the interior of the dishwasher 410 via a vent line 436.

15 Fresh water 430 is sucked out of the fresh-water tank 426 at the induction point 438 in order to rinse the item 414 being washed with cold or else with heated fresh water 430, by means of a fresh-water pump 438, and is supplied to the item 414 to be washed via a
20 washing system for fresh water 440 and a plurality of nozzles for rinsing 442.

Analogously to the example illustrated in Figure 3, the arrangement shown in Figure 4 also once again has a
25 computer system 310 with a central processor unit 312 and a data memory 314. The computer system is connected via a main control line 316 to the dishwasher 410, so that all the major functions of the dishwasher 410 can be controlled via the computer system 410. In addition,
30 the arrangement has two electrical power supplies 444, 446 for the pumps 420 and 438, as well as electrical power supplies 448 and 450 for the heating elements 418 and 432. The functions of the electrical power supplies 444, 446, 448, 450 correspond to that of the power
35 supplies 322, 324, 326, 328, 330 in Figure 3. The power of the electrical power supplies 444, 446, 448, 450 can once again be set by means of externally controllable

electrical power regulators 452, 454, 456, 458, which can once again be driven by the computer system 310.

Furthermore, the tanks 416 and 430 each have
5 temperature sensors 318, whose signals can be detected by means of a measured-data detection unit 320, which can be read by the computer system 310.

Analogously to the description relating to Figure 3,
10 the method according to the invention can also be implemented with the arrangement illustrated in Figure 4. Once again, a plurality of power levels are assigned to the electrical load elements 418, 420, 432 and 438. As described above, in this case as well,
15 these power levels can be predetermined in a fixed form at this stage in the form of electrical circuits, for example in the power controllers 452, 454, 456 and 458, between which it is just necessary to switch in order to apply the appropriate power levels to the load
20 elements 418, 420, 432 and 438.

In the starting phase of the dishwasher 410, the washing liquid in the tank for the washing lye 416 must first of all be heated to the operating temperature.
25 This washing lye is required first of all during operation, followed by the fresh water 430. Thus, analogously to the method described above, the heating element 418 once again first of all has an electrical power corresponding to the maximum power level applied
30 to it, while in contrast lower power levels are applied to the other load elements 420, 432 and 438. For example, the pumps 420, 438 can thus be switched off completely in this starting phase, that is to say they have zero power applied to them. Since the fresh water
35 430 is also required at an increased temperature during operation, it is, however, worthwhile not completely setting the power level for the heating element 432 to zero, so that the fresh water 430 in the fresh-water

tank 426 is also slowly heated up, in order to be available later during rinsing operation.

As soon as the temperature sensor 318 and the measured-
5 data detection unit 320 signal that the temperature in
the washing lye tank 416 has reached the desired
temperature, the computer system 310 starts the
switched-on phase, and the dishwasher 410 is ready to
operate. The regular power levels are then applied to
10 the load elements 418, 420, 432 and 438. The further
operating phases, which have already been described
above, can also be carried out in a corresponding
manner using the energy-saving method according to the
invention. In this case, it should be noted that the
15 regular power levels for the individual load elements
418, 420, 432 and 438 may be chosen to be different in
the different operating phases of the dishwasher 410.
For example, the regular power level of the fresh-water
pump 438 in the phase of cleaning the item 414 to be
20 washed with washing lye from the tank 416 can thus be
set to zero, since no fresh water 430 is applied to the
item 414 to be washed in this phase. The regular power
of this pump 438 is then reduced in a corresponding
manner during rinsing operation. Alternatively, the
25 regular power level for this pump may, however, also be
kept constant.

The method can thus be matched in a simple manner to
the various operating phases of the single-chamber
30 dishwasher 410. Load regulation in the event of a
discrepancy between the individual operating parameters
and their respective nominal values during operation
can be carried out in a manner corresponding to the
method according to the invention as described above.

Table 1: Typical electrical power levels for the loads in a dishwasher corresponding to the prior art, during normal operation:

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| | |
|---------------------------------------|------------------|
| Heating for precleaning 14 | 12 kW |
| Heating for main cleaning 18 | 9 kW |
| Heating for pump rinsing 22 | 3 kW |
| Heating for continuous-flow heater 26 | 8 kW |
| Heating for drying 33 | 9 kW |
| Pumps 15, 19, 23 | 2 kW each = 6 kW |
| total power | 47 kW |

Table 2: Examples of power applied to individual loads on the basis of the method according to the invention, in comparison to the prior art:

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| | P_{imax} P_{ireg} P_{imin} | Starting phase | Switched- on phase | Load regulation phase | Prior art |
|---|---|-------------------|-----------------------|-----------------------------|-----------|
| Heating for precleaning (14) | 24 9 0 | 24 | 9 | 0 | 24 |
| Heating for main cleaning (18) | 15 6 0 | 15 | 6 | 15 | 15 |
| Heating for pump flushing (22) | 6 2 0 | 6 | 2 | 6 | 6 |
| Heating for continuous-flow heater (26) | 18 16 0 | 0 | 16 | 16 | 18 |
| Heating for drying (33) | 9 6 0 | 0 | 6 | 0 | 9 |
| Pumps (15, 19, 23) | 6 6 0 | 0 | 6 | 6 | 6 |
| Sum | | 45 kW | 45 kW | 43 kW | 78 kW |

List of reference symbols

- | | |
|----|---|
| 1 | Inlet zone |
| 2 | Precleaning zone |
| 3 | Main cleaning zone |
| 4 | Pump rinsing zone |
| 5 | Fresh-water rinsing zone |
| 6 | Heat recovery zone |
| 7 | Dry zone |
| 8 | Outlet zone |
| 9 | Item being washed |
| 10 | Transport device, item being washed |
| 11 | Transport device, for example endless belt |
| 12 | Inlet trough |
| 13 | Tank for cleaner solution |
| 14 | Heating for precleaning |
| 15 | Pump for precleaning |
| 16 | Spraying system for precleaning |
| 17 | Tank for cleaner solution for main cleaning |
| 18 | Heating for main cleaning |
| 19 | Pump for main cleaning |
| 20 | Spraying system for main cleaning |
| 21 | Tank for solution, pump rinsing zone |
| 22 | Heating for pump rinsing zone |
| 23 | Pump for pump rinsing zone |
| 24 | Spraying system for pump rinsing zone |
| 25 | Continuous-flow heater for fresh-water rinsing |
| 26 | Heating, continuous-flow heater for fresh water |
| 27 | Mains connection for fresh water |
| 28 | Spraying system for fresh-water rinsing |
| 29 | Heat exchanger, exhaust air/fresh water |
| 30 | Exhaust air fan |
| 31 | Direction of the air flow |
| 32 | Fan in the dry zone |
| 33 | Heating in the dry zone |
| 34 | Direction of the air flow |

- 35 Outlet trough for removal of the item being washed

- 110 Multiple chamber dishwasher

- 210 Assignment of an electrical total power p_{\max}
- 220 Assignment of power levels p_{ij}
- 230 Determination of the optimum combination of power levels p_{ij}
- 240 Setting of the power $p_{ij}(B)$ for each load element

- 310 Computer system
- 312 Central processor unit
- 314 Data memory
- 316 Main control line
- 318 Temperature sensors
- 320 Measured data detection unit
- 322 Electrical power supply
- 324 Electrical power supply
- 326 Electrical power supply
- 328 Electrical power supply
- 330 Electrical power supply
- 332 Externally controllable electrical power regulator
- 334 Externally controllable electrical power regulator
- 336 Externally controllable electrical power regulator
- 338 Externally controllable electrical power regulator
- 340 Externally controllable electrical power regulator

- 410 Single-chamber dishwasher
- 412 Basket
- 414 Item being washed
- 416 Tank for washing lye

| | | | | |
|-----|--------------------------------------|------------|-------|--|
| 418 | Heating element for washing lye | | | |
| 420 | Circulation pump | | | |
| 422 | Washing system for washing lye | | | |
| 424 | Nozzles for washing lye | | | |
| 426 | Fresh-water tank boiler | | | |
| 428 | Filling valve | | | |
| 430 | Fresh water | | | |
| 432 | Heating element for fresh-water tank | | | |
| 434 | Coverage level | | | |
| 436 | Vent line | | | |
| 438 | Induction pump | | | |
| 440 | Washing system for fresh water | | | |
| 442 | Nozzles for rinsing | | | |
| 444 | Electrical power supply | | | |
| 446 | Electrical power supply | | | |
| 448 | Electrical power supply | | | |
| 450 | Electrical power supply | | | |
| 452 | Externally controllable | electrical | power | |
| | regulator | | | |
| 454 | Externally controllable | electrical | power | |
| | regulator | | | |
| 456 | Externally controllable | electrical | power | |
| | regulator | | | |
| 458 | Externally controllable | electrical | power | |
| | regulator | | | |